Reg. No._____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MAY 2017

Course Code**: CH202**

Course Name**: PROCESS HEAT TRANSFER (CH)**

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two questions. Each question carries 15 marks.

1. a) The composite wall of an oven consists of three materials, two of which are of known thermal conductivity, $k_A = 20$ W/m.K and $k_c = 50$ W/m.K and known thickness, $L_A = 0.3$ m and $L_c = 0.15$ m. The third material, B, which is sandwiched between materials A and C, is of known thickness, $L_B = 0.15$ m, but unknown thermal conductivity k_B. Under steady state conditions, measurements reveal an outer surface temperature of 20°C, an inner surface temperature of 600°C, and oven air temperature of 800°C. The inside convection coefficient h is known to be 25 W/m^2.K. Determine the value of k_B. (12)

b) Sketch hydrodynamic and thermal boundary layer for a hot fluid over a flat plate for Prandtl number greater than 1. (3)

2. a) An electrically heated sphere with diameter D = 6 cm is exposed to ambient air at $T_\infty = 25°C$ providing a heat transfer coefficient of 20 W/m^2-K. The surface of the sphere is to be maintained at temperature $T_i = 125°C$. Calculate the heat loss for the following cases:

(a) The bare sphere (uninsulated)

(b) Sphere covered with an insulation (k = 1 W/m-K) having a radius corresponding to the critical radius of insulation for the sphere. (10)

b) Explain the significance of Heisler charts in solving transient heat conduction problems. (2)

c) Distinguish between Critical thickness of insulation and optimum thickness of insulation. (3)

3. a) A person is found dead at 5pm in a room whose temperature is 20^{0}C. The temperature of the body is measured to be 25^{0}C, when found, and the heat transfer coefficient is estimated to be 8 W/m^{2}K. Modelling the human body as a 30 cm diameter, 1.7m long cylinder, calculate actual time of death of the person. Take thermo physical properties of the body K=6.08 W/mK, density=900 Kg/m^3, C=4000J/KgK .Body temperature=37^{0}C. (10)

b) Give the condition under which lumped capacity assumption may be used in the analysis of unsteady state heat conduction problems. (2)

c) Give the significance of Reynold's number and Rayleigh number with respect to forced and free convection. (3)

PART B

Answer any two questions. Each question carries 15 marks.

4. a) Air at 70°C and essentially atmospheric pressure is flowing through a 15cm x 10cm rectangular duct at a velocity of 12m/s. If the wall temperature of the duct is 32°C and the length of the duct is 50m, calculate the drop on the air temperature.

Properties of air at 70°C

Density = 1.05 kg/m^3

Prandtl number = 0.71

Cp = 1.009 KJ/kg.K

Kinematic viscosity = 20 x 10^{-6} m^2/s

K = 0.029 W/mk (12)

b) Give the significance of Grashof number. Explain the role of Grashof number in determining whether force or free convection is dominant in a particular case of combined forced and free convection. (3)

5. a) A counter flow double pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2, determine the length of the heat exchanger required to achieve the desired heating. Properties: Specific heat of water and geothermal fluid 4.18 and 4.31 kJ/kg°C respectively. (9)

b) Justify the use of LMTD correction factor in the analysis of multi-pass heat exchangers. (3)

6. a) A truncated cone has the top and bottom diameters as 10 cm and 20 cm respectively. The height of the truncated cone is 10 cm. Calculate the shape factor between the top surface and the side, and between the side surface and itself. (9)

b) State Planck's law. Plot the variation of spectral emissive power against wavelength for a black body. Obtain the expression for wavelength corresponding to maximum emissive power. (6)

PART C

Answer any two questions. Each question carries 20 marks.

7. a) Derive the expression for temperature distribution and heat flux for fin of uniform cross section for a fin with insulated tip. (15)

b) Define fin effectiveness and fin efficiency. Obtain the expressions for effectiveness and efficiency of a fin with insulated tip. (5)

8. a) An evaporator operating at atmospheric pressure is desired to concentrate the feed from 5% to 20% solute (by weight) at a rate of 5000 Kg/hr. Saturated steam at a pressure corresponding to a temperature of 399 K is used. The feed is at 298 K. The overall heat transfer coefficient is 2350 W/m^2 K. Calculate the capacity, economy, steam consumption and heat transfer area to be provided.
Latent heat of vaporization of solvent at atmospheric pressure=2257 KJ/Kg

Specific heat of feed=4.187 KJ/Kg K

Latent heat of condensation of steam at 399K=2185 KJ/Kg (14)

b) Discuss the merits and demerits of the following feeding arrangements in a multiple effect evaporator i). Forward feed ii). Backward feed iii) mixed feed. (6)

9. a) Derive the Nusselt equation for the average coefficient of heat transfer at the condensing film in a vertical cooled tube. (10)

b) Dry saturated steam at a pressure of 2.45 bar condenses on the surface of a vertical tube of height 1m. The tube surface temperature is kept at 117^0C. Estimate the thickness of the condensate film and the local heat transfer coefficient at a distance of 0.2m from the upper end of the tube.

The properties of water at 2.45 bar are

saturated vapour: Tsat=127^oC,density=1.368 kg/m^3, hfg=2183kJ/kg

saturated water:Tf=(117+127)/2=122^0C

density=941.6 kg/m^3, $\mu=227\times10^{-6}$ Ns/m^2, $k_l=687\times10^{-3}$W/mK (10)

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